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ABSTRACT

Twelve learning disabled (9-12 years old) boys were identified according to special class placement, WISC-R (Wechsler Intelligence Scale for Children-Revised) and performance measures. A group demonstrating a verbal WISC-R deficit was sex- and age-matched with a normal group. Electroencephalograms (EEGs) were collected while these individuals performed two verbal, one visuospatial, and one interfering verbal/visuospatial tasks. Several previous investigations suggested that the slow wave theta component of the EEG is more predominant during visuospatial processing. Results demonstrated that the learning disabled boys, in contrast to normal boys, show significantly higher levels of such brain electrical activity during performance of both verbal tasks and the one purely visuospatial task. Theta level activity in normal boys was enhanced only during the performance of the verbal/visuospatial interference task. The enhancement resulted from more right hemisphere activity, perhaps due to the interference. This was the only task in which differences between groups was not significant. The data suggest a predominant visuospatial processing mode in learning disabled boys during performance of both verbal and visuospatial tasks. The only enhancement in normals was in the task which has an interfering visuospatial direction. Findings support other performance related findings which suggested learning disabled individuals have a predominant visuospatial processing strategy. (Author/CL)

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VERBAL DEFICIT IN LEARNING DISABILITIES: ELECTROPHYSIOLOGICAL EVIDENCE FOR VISUOSPATIAL PROCESSING PREDOMINANCE

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ABSTRACT

Learning disabled boys were identified according to special class placement, WISC-R and performance measures. A group demonstrating a verbal WISC-R deficit was sex and age-matched with a normal group. EEG was collected while these individuals performed two verbal, one visuospatial and one interfering verbal/visuospatial tasks. Several previous investigations suggested that the slow wave theta component of the EEG is more predominant during visuospatial processing. The investigators demonstrated that the learning disabled boys, in contrast to normal boys, show significantly higher levels of such brain electrical activity as they performed both of the verbal tasks and the one purely visuospatial task. Theta level activity in normal boys was enhanced only during the performance of the verbal/visuospatial interference task. The enhancement resulted from more right hemisphere activity, perhaps due to the interference. This was the only task in which differences between groups was not significant. The data suggest a predominant visuospatial processing mode in learning disabled boys during performance of both verbal and visuospatial tasks. The only enhancement in normals was in the task which has an interfering visuospatial direction. These findings support other performance related findings which suggested learning disabled individuals have a predominant visuospatial processing strategy.

The investigation provided electrophysiological evidence for a predominance in learning disabled boys to more actively engage visuospatial (simultaneous) patterns of processing during several cognitive tasks when compared to normal age-matched control boys. Recent work by Gevins, Zeitlin and Doyle (1979), Rugg and Venables (1980) and Rugg and Martin (1982), suggests that slow wave theta band EEG activity (4-8 cycles/second) increases as a function of visuospatial task performance when compared to activity during verbal task performance. The intent was to demonstrate that the learning disabled group will generally utilize a more visuospatial pattern of processing even during verbal task performance.

The greater portion of electrophysiological studies of learning disabled populations has been done by utilizing the standard clinical EEG protocol to identify abnormalities in brain electrial activity (reviewed by Hughes, 1982). More recently, investigators have begun analysis of brain electrical activity while subjects are engaged in a variety of cognitive tasks. Such research is focused upon delineation of the electrophysiological indices of functional brain organization during various cognitive task demands (reviewed by Gevins and Schaffer, 1980). This technology has been applied to investigations of learning disabled subjects and has provided evidence for differences in their brain electrical activity when compared to normal control subjects (Elliot, Halliday and Callaway, 1978; Kaye, John, Ahn and Prichep, 1981 and Duffy, Denckla, Bartels and Sandini, 1980). The utility of such investigations is in the demonstration of quantifiable electrophysiological indices of differences in how individuals predominate in cognitive processing strategies during a variety of task demands.

The investigators selected several cognitive tasks having varying degrees of verbal and visuospatial content in order to assess the relative difference between learning disabled and normal boys in theta band brain electrical activity. We hypothesized that the learning disabled group would demonstrate higher levels of theta activity during the cognitive tasks they were expected to perform. As suggested in the previously discussed literature, such a result would indicate a predominant visuospatial strategy in complex task performance.

METHOD

Subjects

Twenty-four boys were identified by school personnel according to Ohio State learning disability criteria. Twelve learning disabled boys between the ages of 9 and 12 were chosen because they were receiving daily special education services. Each boy demonstrated at least a two year discrepancy between their assessed WISC-R ability and actual performance. In addition, each boy had at least a 10 point (mean = 12) difference between verbal and performance scores on the WISC-R; verbal scores being the lower. Learning disabled boys were then matched for age and handedness (Oldfield, 1971) with normal boys by the experimenter and school personnel. Normal boys had no history of school related problems, and were performing at their expectancy level according to group administered achievement tests. Informed consent was received from the children and their parents. Data collection was conducted within the school to minimize anxiety.

Tasks

Four tasks were selected to be administered two times in the data collection. Stimulus items were different for each administration. Two tasks were chosen for their high verbal content, one for high visuospatial processing demand and one for its high verbal/visuospatial interference. Verbal tasks were selected from the Peabody Individual Achievement Test (PIAT), including the reading comprehension and the spelling subtests. Reading requires silent reading and a four-item forced-choice picture representation of what has been read. The Spelling task requires performance on a four-item forced-choice response following auditory presentation. Both tasks are highly verbal in nature, yet dependent upon some degree of visuospatial ability. Mooney Faces (Mooney, 1956 and Lansdell, 1968), the visuospatial task, requires discrimination of male and female faces represented in pure black and white tones with no shaded gradations. Stroop stimuli (Stroop, 1935) were utilized as the verbal/visuospatial interference task. The Stroop task is composed of color names in interfering ink colors. Instructions were randomly given to name the word (verbal processing) or the ink color (visuospatial) to maximize the interference. An 80% correct performance criterion was established to assure subjects appropriate task behavior. The performance criterion assures sufficient cognitive difficulty to engage the predominant processing strategy. PIAT items were selected individually according to performance levels and were not repeated during the second administration. Thus, two samples of EEG were recorded during each cognitive task for at least one minute of task performance.

Procedure

The EEG recording was accomplished by utilizing an Electro-Cap(r) for electrode placement. Two channels of EEG data were recorded from bilateral electrode sites P3-T5 and P4-T6 (according to the International 10-20 System; Jasper, 1958), the left ear lobe serving as ground. The bipolar electrode placement was selected because of its position in overlaying the association cortex referred to as Wernicke's Area of the left hemisphere and the right homologue. These areas are related to higher cognitive processing associated with language, more predominantly processed on the left and visuospatial material, more predominantly processed on the right side (Luria, 1977 and 1978). However, we also want to note that nearly all higher cognitive processes are a combination of both types of activity and will therefore be represented by brain electrical activity in both hemispheres (Aaron, 1982).

Each task was given to produce at least a one minute sample of EEG during each administration. Tasks were administered in ascending order; subjects then had a brief rest and then each task administered again in descending order. The EEG data were low pass filtered at 40 c./sec. and high pass filtered at .5 c./sec. before recording on F.M. magnetic tape for off-line analysis and permanent storage. The permanently recorded signal was then available for subsequent analog to digital conversion prior to Fourier Transform Spectral Analysis.

The EEG real-time analog data reduction is accomplished with two computer programs; the first for sampling data and the second, for processing the data into a frequency histogram for a final printout.

In addition, the analysis includes software filtering of the artifact. The final numerical value given by the computer reflects the percentage of overall, artifact free, EEG activity in each frequency band for a ten second epoch of data sampling. For the purposes of this report, two ten-second artifact free samples of EEG were statistically analyzed for differences between the normal and learning disabled groups in the theta frequency band.

RESULTS AND DISCUSSION

Criterion levels of at least 80% performance accuracy were achieved by subjects from both groups. Therefore, we assumed subjects were processing the assigned tasks in their most predominant manner. The percentage of total power represented in the theta frequency band was then subjected to an arcsine transformation for more appropriate analysis of variance (ANOVA) for each task (factors of group administration and hemisphere, collapsed over the two ten second epochs).

The ANOVA comparing the transformed theta power values during the four tasks demonstrated several interesting results. The data were collapsed over the factors of first and second administration and hemisphere because main effect differences were not achieved nor were there interactions with those variables (See Table 1). Robust group differences in theta activity were achieved in the reading subtest ($F = 34.159$; $df = 1,160$; $p < .001$), the spelling subtest ($F = 18.761$; $df = 1,160$; $p < .001$) and the Mooney Faces task ($F = 19.440$; $df = 1,160$; $p < .001$). In all cases, the learning disabled group showed higher levels

of theta activity. However, no significant difference was achieved in the Stroop Card interference task ($F = 3.116$; $df = 1,160$, $p > .05$) between the two groups of boys (See Figure 1).

The data are interesting in that they suggest the learning disabled population approaches both spelling and reading tasks with a similar pattern of difference in slow wave brain electrical activity when compared to the normal boys. In addition, the pattern continues when the two groups are compared in the purely visuospatial task of Mooney Faces. The data suggests a more predominant visuospatial pattern of processing characteristics in the learning disabled group. In fact, the normal group continues to suppress the theta activity even in processing the purely visuospatial Mooney Faces task. Although the ANOVA demonstrates only a direction towards a significant difference between hemispheres in the Mooney Faces task, the learning disabled group shows a $\overline{X}$ right hemisphere theta = 16.66 and $\overline{X}$ left = 14.8. When compared to the normal group, showing $\overline{X}$ right = 12.32 and $\overline{X}$ left = 12.00, it becomes more obvious that the learning disabled group tends to show a right hemisphere advantage in theta production during the visuospatial task. This left hemisphere decrease in the learning disabled during Mooney Faces may account for the overall lower level of theta activity when compared to the other tasks (See Figure 1). These suggestions have previously been made by other investigators utilizing a variety of dichotic listening and tachistoscopic methods (Witelson, 1977; Pirozzolo and Rayner, 1977; Keefe and Swinney, 1979; and Pirozzolo and Raynder, 1979). This

investigation provides electrophysiological evidence for a learning disabled population with a verbal deficit to have a more visuospatial orientation.

The Stroop Card interference task provides an interesting contrast in brain electrical activity when compared to the other tasks. The Stroop task can be described as one which induces interference between a predominantly visuospatial and verbal processing, dependent on the instruction. The Stroop data in the present investigation were generated by random directions to report the word or the color during the one minute task, which varied the interference between verbal and visuospatial stimulus items. Although the normal group seemed to demonstrate a similar pattern of theta level activity, when the data were collapsed over the variable of hemispheres, they reflect a nonsignificant right hemisphere advantage (right $\overline{X}$ = 15.53, left $\overline{X}$ = 13.09). This is the only task in which this hemispheric direction exists in normals and nicely reflects the typical pattern of color (spatial) interfering with the word (verbal). The change is enough to keep the difference between groups from achieving significance. Even though the theta level in the learning disabled continued to be greater, reflecting overall visuospatial predominance, there is only a slight difference comparing right to left hemisphere (right $\overline{X}$ = 16.21, left $\overline{X}$ = 17.71).

SUMMARY

The data provides electrophysiological evidence, supporting performance related measures which previously suggested a more predominant visuospatial

mode of processing information among a subgroup of the learning disabled population having a verbal deficit. Such information has implication to intervention strategies with learning disabled individuals, especially in light of the demonstrated interference among the learning disabled group when confronted with instructions which tended to hinder them in engaging their predominant processing strategy in the Stroop task. Although these children are able to experience a degree of success when material is at the appropriate performance level, their potential to learn may well be enhanced if continued effort is made to provide alternative visuospatially oriented materials and performance requirements.

Understanding the differences in the way learning disabled children process information provides insight towards modifying both instructional methodology and materials. The demand for conformity to a single mode of learning ought not be a direction we reinforce; rather, the diversity of learner characteristics should support our focus upon providing a variety of methods and materials for the most productive learning among all individuals. Identification of the more predominant processing characteristics in learning disabled children will enhance our ability to provide more adequate intervention strategies.

Table 1

Mean Theta Band EEG (Arc-sine transform)

	Learning Disabled	Normal
PIAT Reading	18.61	13.52
PIAT Spelling	17.48	13.65
Mooney Faces	15.73	12.16
Stroop Stimuli	16.98	14.31

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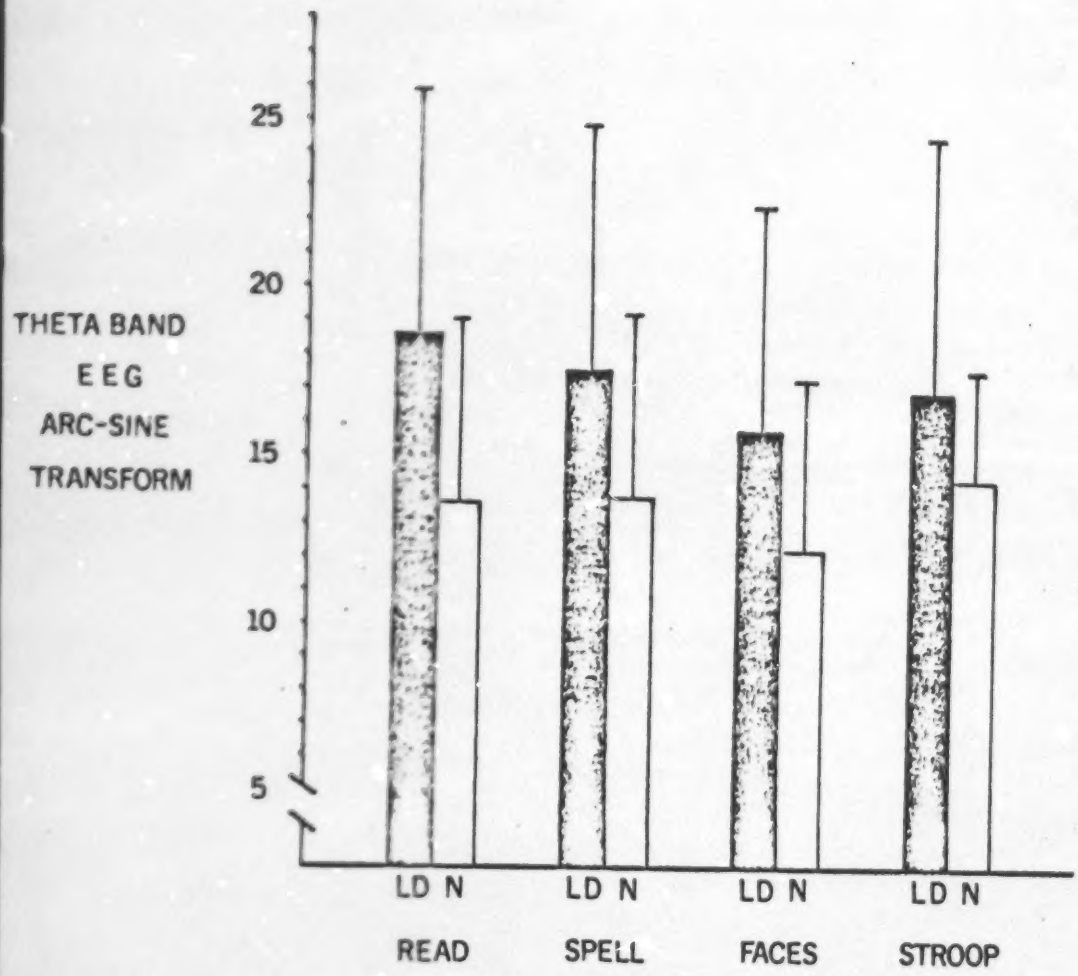

FIGURE 1
ARC-SINE TRANSFORMATION OF THE MEAN PERCENTAGE AND STANDARD DEVIATION OF THETA BAND EEG ACTIVITY IN LEARNING DISABLED (LD) AND NORMAL (N) BOYS DURING THE PERFORMANCE OF FOUR COGNITIVE TASKS.